From Infrastructure to Cooperative Systems

Steven E. Shladover

California PATH Program
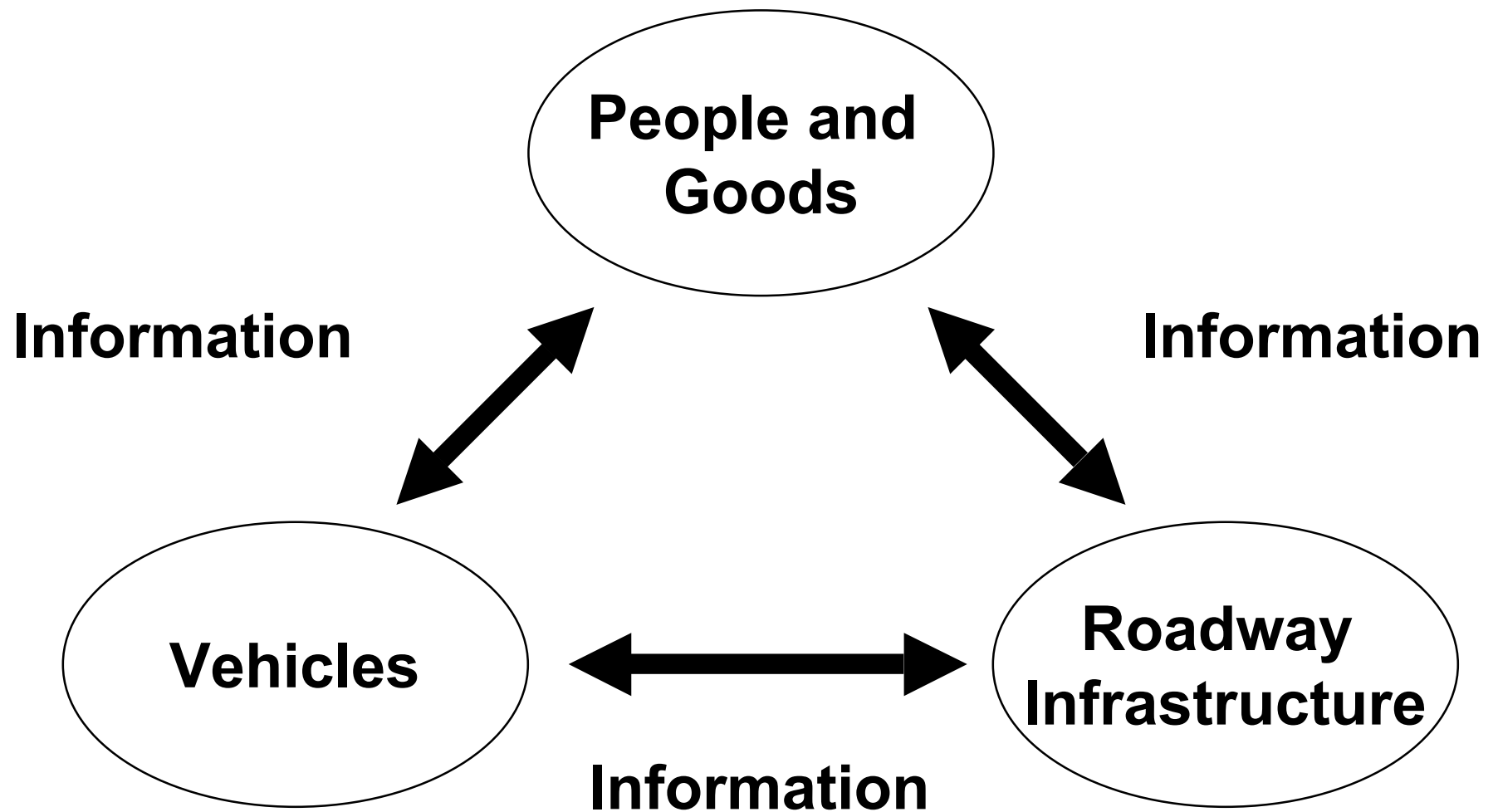
Institute of Transportation Studies

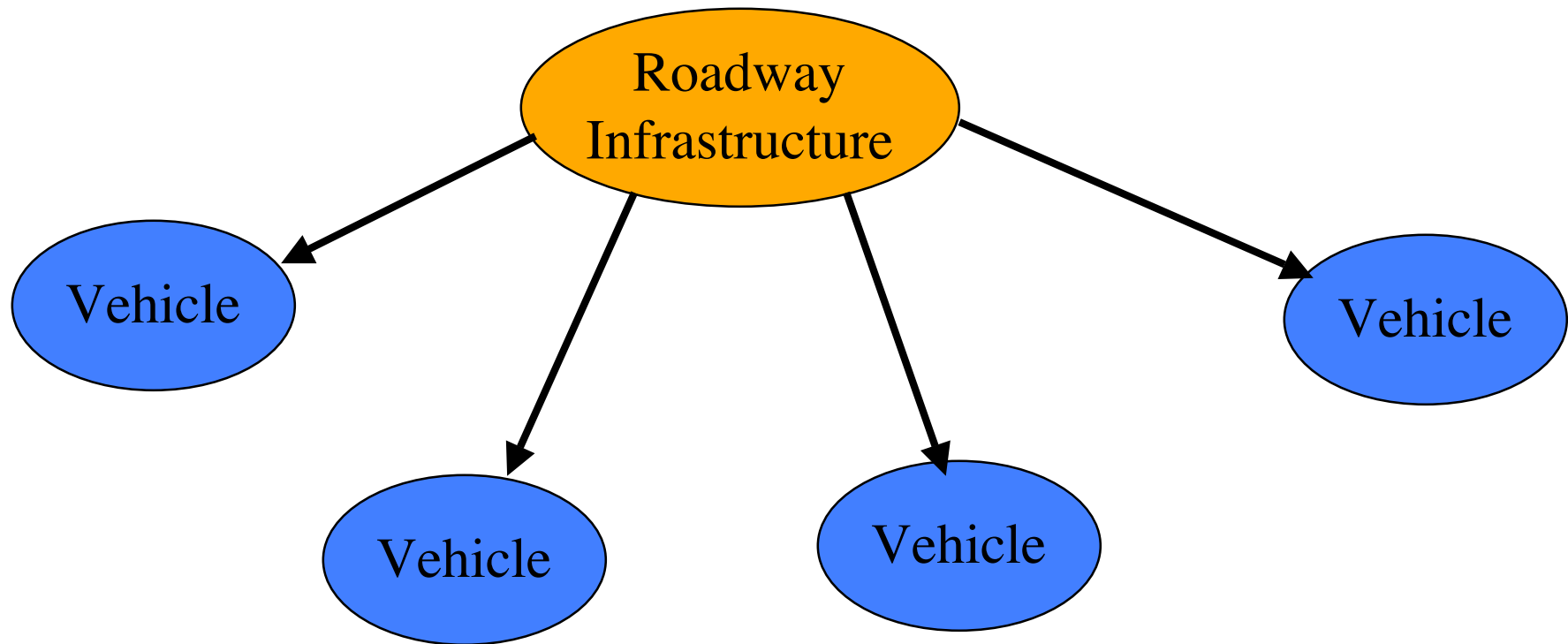**University of California, Berkeley**

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The Transportation System is Not Just Infrastructure or Vehicles
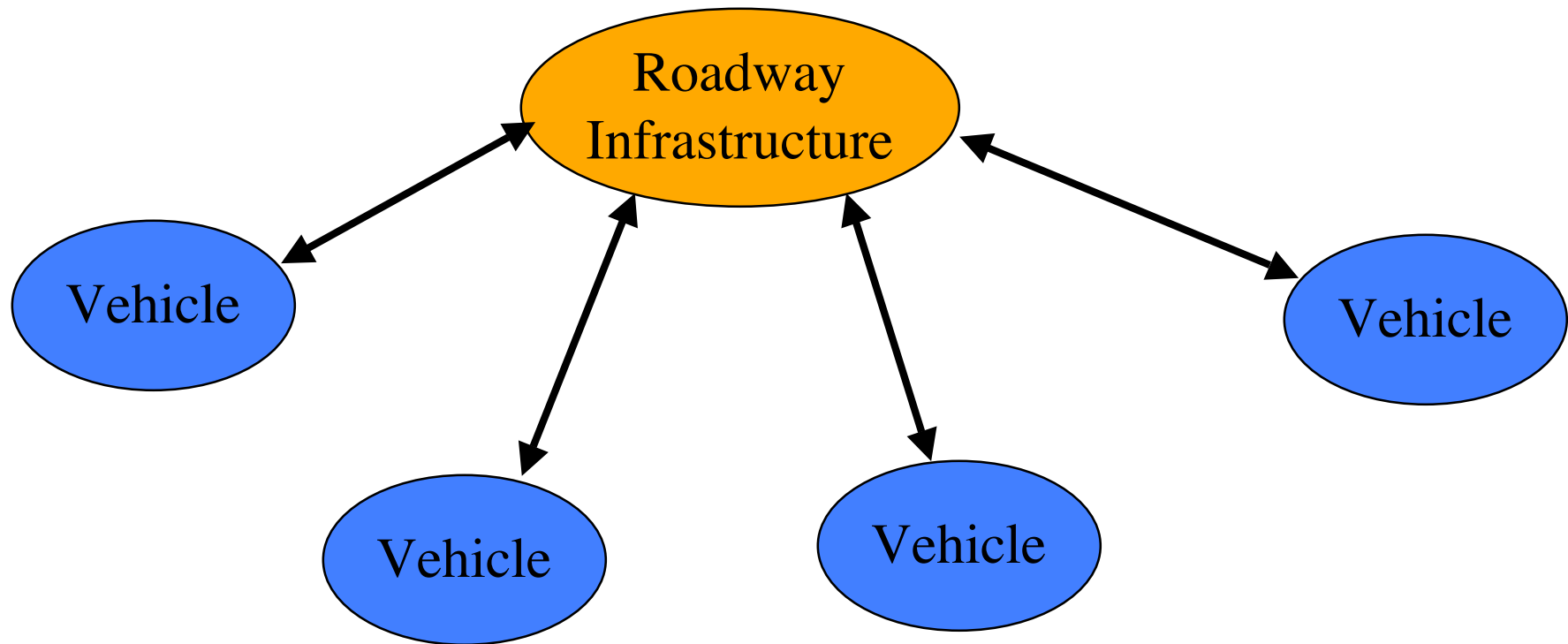
Levels of Cooperation

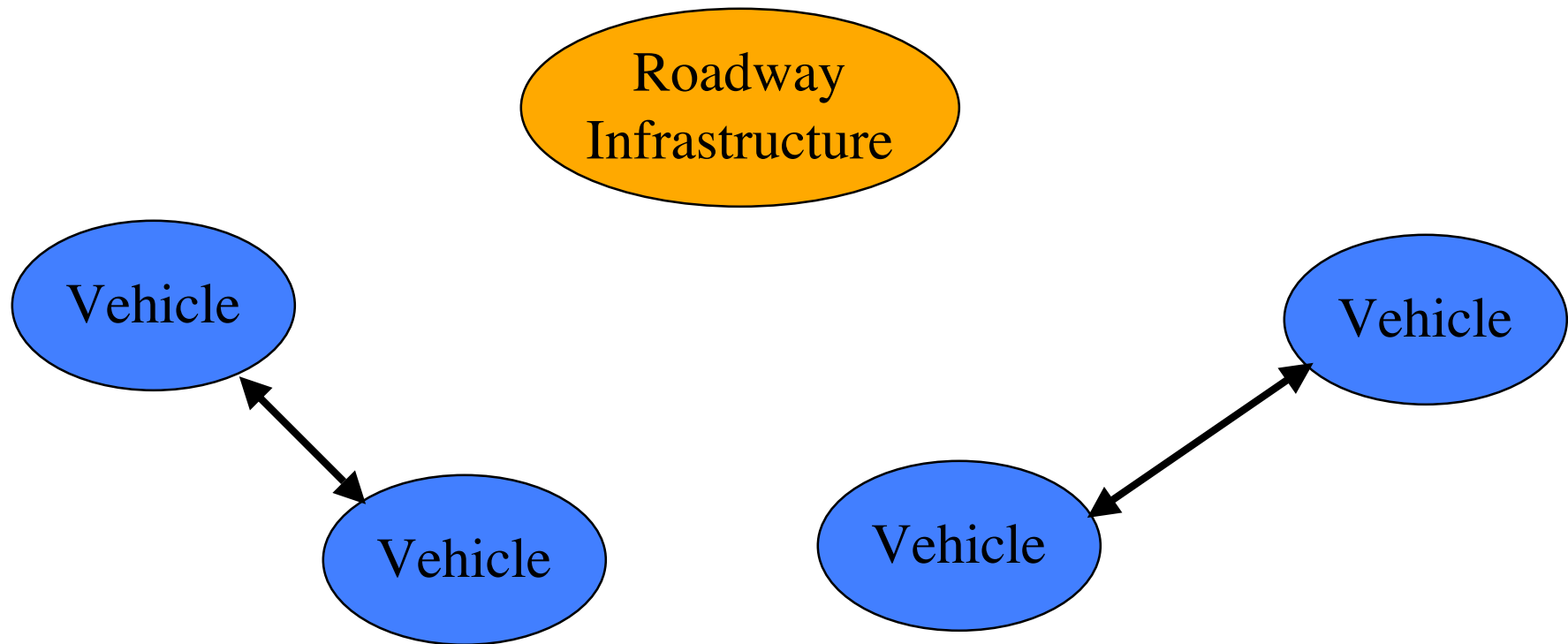**Infrastructure → Vehicle, broadcast only**

Levels of Cooperation

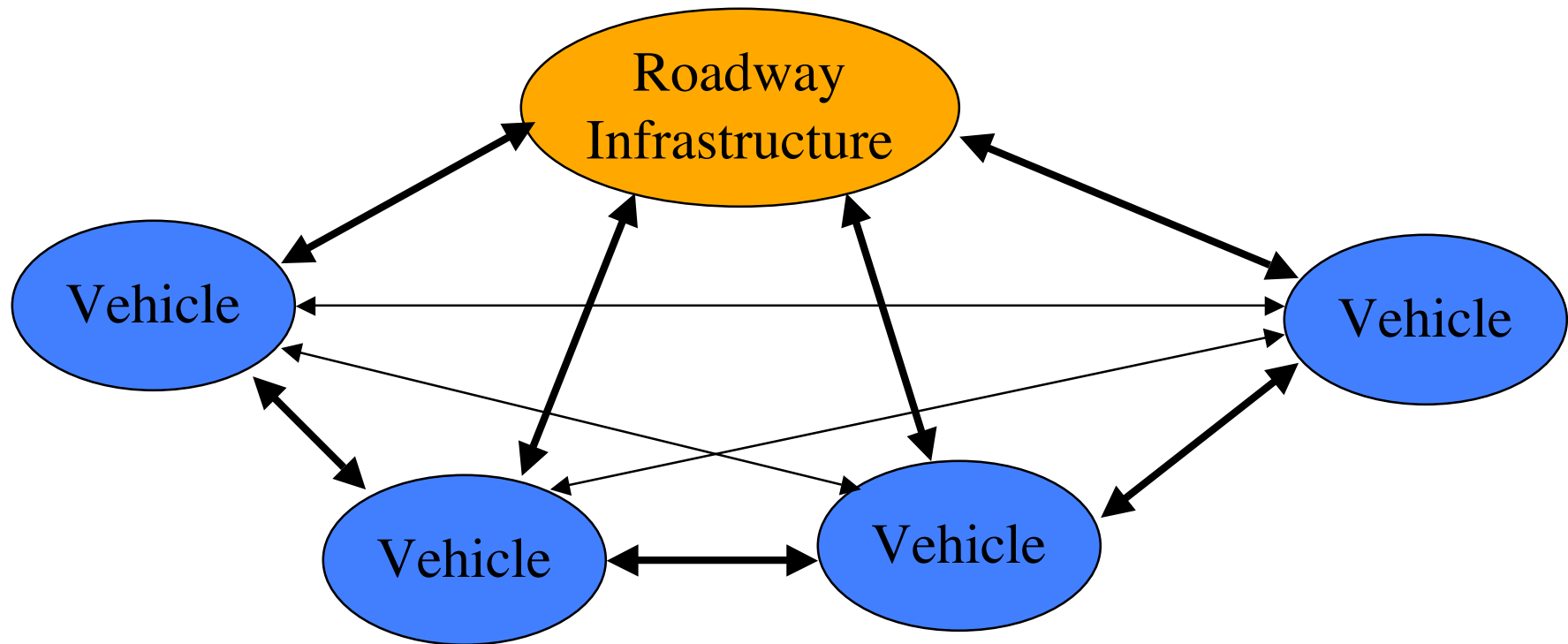**Infrastructure→ Vehicle →Infrastructure**

Levels of Cooperation

Vehicle → Vehicle only

Levels of Cooperation

Comprehensive Network

Which Functions are Best Performed Where?

- **Functions such as:**
  - **Sensing current conditions**
  - **Alerting drivers**
  - **Controlling (traffic flows or vehicles)**

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- **Functions such as:**
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- **Criteria such as:**
  - **Technical feasibility**
  - **Safety/Reliability/Fault tolerance**
  - **Costs (and alignment with benefits)**
  - **Institutional/Deployment feasibility**

Vehicle-Based Advantages

- More salient user interfaces possible (audible and haptic, as well as visual)

- Characteristics can be tailored to individual driver needs and preferences

- No public investments or political decisions needed to effect deployment

- Can intervene directly in vehicle movements if necessary

- Large vehicle production volumes can provide long-term economies of scale

Infrastructure-Based Advantages

- Investments can be targeted at "hot spots" with most serious safety problems

- Sensors can detect <u>all</u> relevant vehicles and communication systems can address them

- Warning displays can help <u>all</u> drivers, regardless of vehicle condition or equipment or driver propensity to invest in safety

- Initial costs of normal infrastructure are so large that incremental costs to add ITS capabilities are small by comparison, easing the investment decisions

Integrated System Advantages

- **Combine strengths of both vehicle and infrastructure systems, to do what neither can do well alone**

- **Complementary investments in vehicles and infrastructure can make <u>each</u> more cost effective than if it had to do <u>everything</u> itself**

- **Opportunity to find best cost-performance trade-off at societal/system level**

Integrated System Challenges

- **Standards needed to govern the interfaces**
- **Coordination of decision making needed for deployment**
- **Different motivations and time scales for public and private sector deployment decisions**
- **Risk of low return on investment for the "side" that goes first, if the "other side" does not follow quickly**
- **Difficulty of balancing allocations of costs and benefits between vehicle and infrastructure**

IVI Infrastructure Consortium

- **IVI Infrastructure Consortium Principals**
  - **California DOT (Caltrans)**
  - **Minnesota DOT**
  - **Virginia DOT**
  - **USDOT (FHWA)**

- **Universities conducting the IDS research**
  - **U.C. Berkeley (California PATH, other units)**
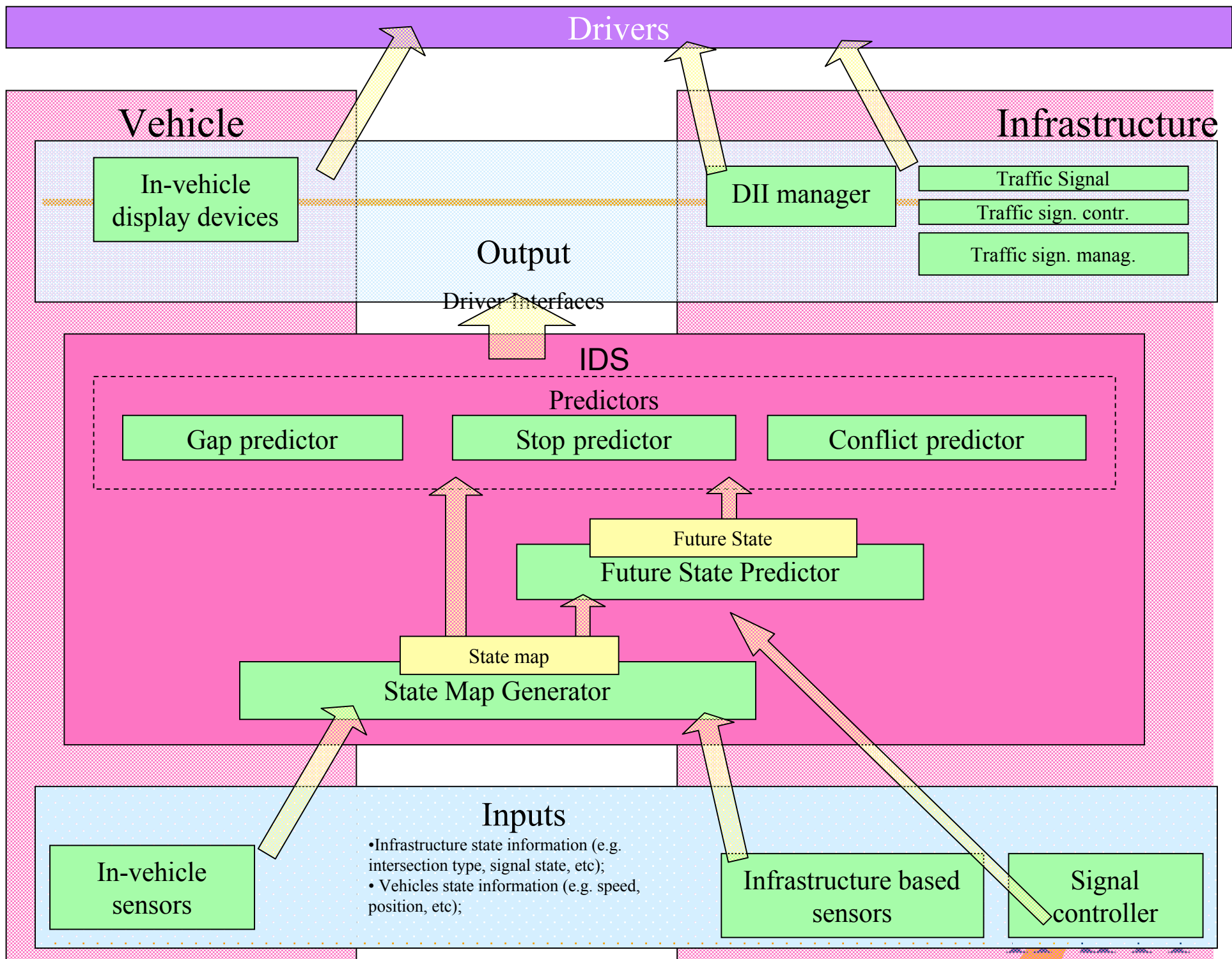 - **University of Minnesota (ITS Institute, other units)**
  - **Virginia Tech (VTTI)**

Intersection Decision Support (IDS): Starting with Infrastructure

- Intersection crashes occur in specific infrastructure settings
- Priority can be given to worst-case sites to provide maximum benefits
- Vehicle-based sensors cannot see around corners, but infrastructure-based sensors can see all approaching vehicles
- Infrastructure-based displays can support all approaching vehicles, regardless of onboard devices
- Wireless transceiver at intersection can communicate with all (equipped) approaching vehicles
- Incremental costs a small fraction of traffic signal implementation costs

Intersection Decision Support (IDS): Advancing to Cooperative

- **Better sensing states of approaching vehicles from both infrastructure and vehicles, possibly identifying driver intentions**

- **Providing more salient (in-vehicle) driver warnings**

- **Customizing alerts for driver needs and preferences (especially older drivers)**

- **Vehicle-vehicle wireless coordination for rural intersections where infrastructure costs may not be warranted**

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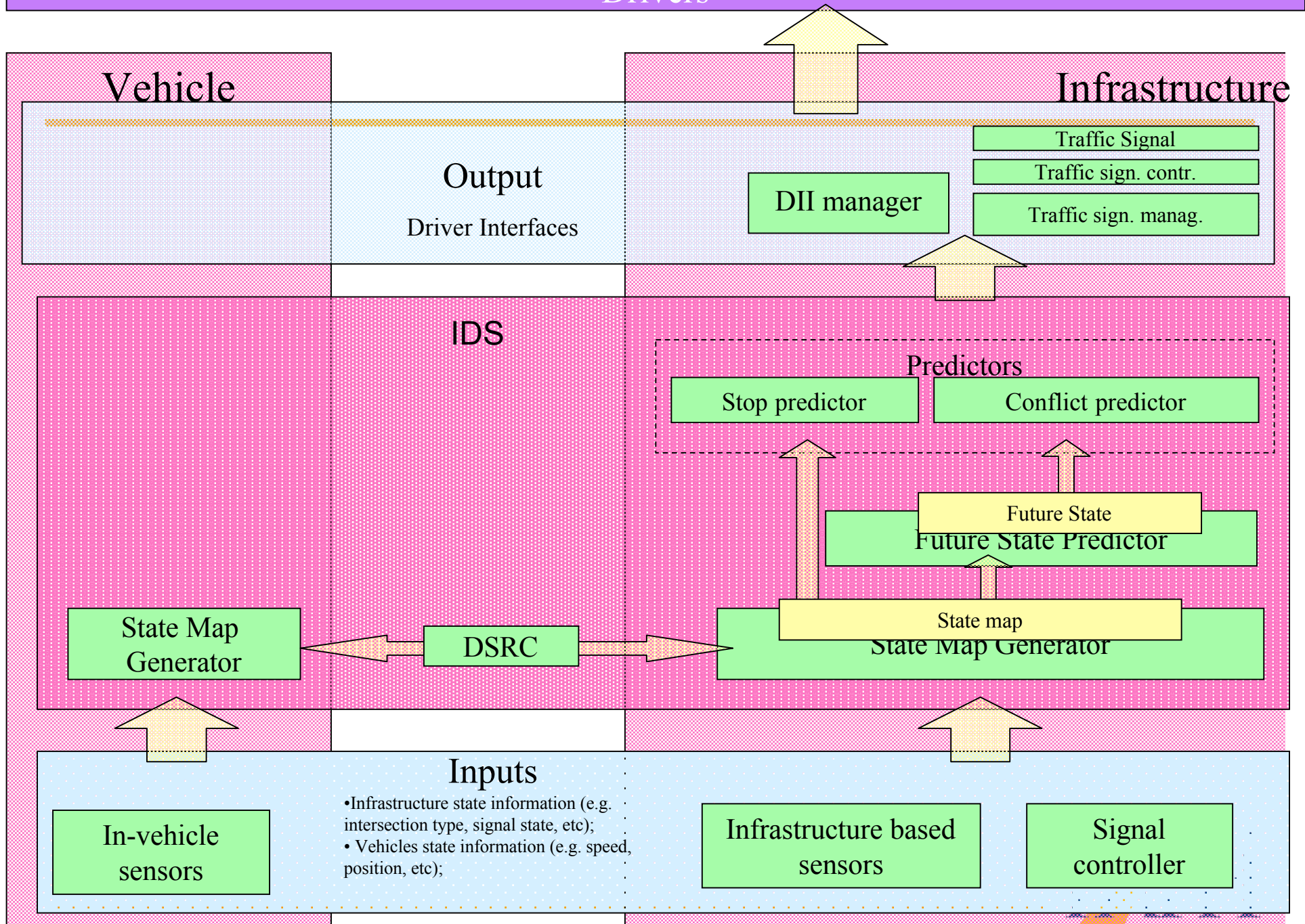
Drivers

Vehicle

Infrastructure

In-vehicle display devices

DII manager

Traffic Signal

Traffic sign. contr.

Traffic sign. manag.

Output

Driver Interfaces

IDS

Predictors

Gap predictor

Stop predictor

Conflict predictor

Future State

Future State Predictor

State map

State Map Generator

Inputs

•Infrastructure state information (e.g. intersection type, signal state, etc);
• Vehicles state information (e.g. speed, position, etc);

In-vehicle sensors

Infrastructure based sensors

Signal controller

Demonstration

Drivers

Vehicle

Infrastructure

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Intersection "State Map" (ideal)

Information	Possible Source(s)
Geometric layout	Static database
Signal phase and timing	Signal controller (Infrast.)
Road surface condition/traction	Infrast. or vehicle sensors
For *each* approaching vehicle:	
• position	Infrast. or vehicle sensors
• speed	Infrast. or vehicle sensors
• acceleration	Vehicle sensors
• response capability	Vehicle data
• driver intention (stop, straight, LT, RT)	Vehicle data (if driver signals)
• driver alertness/awareness	Vehicle data (if equipped)
• driver response capability	?
• driver aggressiveness/time urgency	?

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